WASHINGTON STATE DEPARTMENT OF ECOLOGY

Protecting the Columbia River:

The Need to Retrieve and Immobilize Hanford's High-Level Radioactive Tank Waste

MARCH 1999

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Written by the Oregon Office of Energy's
Nuclear Safety Division,
under a contract with
the Washington Department of Ecology.

(The cover photo shows the inside of
one of Hanford's high-level
radioactive waste storage tanks.)

Overview

The Columbia River. Lewis and Clark first made it famous in the early 1800s. Native Americans have relied on it for food, water and transportation for more generations than any of us know for certain. It was the last obstacle for homesteaders and pioneers on the Oregon Trail. More recently, its water has been used to irrigate millions of acres of arid land and turn it into productive farmland that helps feed people all around the world. It's a popular recreation destination for boating, camping, windsurfing, fishing and swimming. This mighty river is a symbol of the power and beauty of nature, and of the region and its people.

Radioactive and chemically hazardous wastes at the Hanford Nuclear Site pose a severe risk to the Columbia River.

The Columbia River is also a river at severe risk.

Highly radioactive and chemically hazardous waste from the Hanford Nuclear Site in southeastern Washington state presents a serious, long-term threat to the Columbia River and to Northwest residents. We know that some of the most hazardous waste from Hanford – leaked from aging underground storage tanks – has already reached the groundwater and will eventually reach the river. To protect the environment and people along the Columbia River from further damage, the wastes must be removed from the tanks and immobilized.

"Hanford's contamination and waste pose an ominous threat to the Columbia River and to the people of both Washington and Oregon. This is very much a public health issue as well as an environmental issue." Letter from Washington Governor Gary Locke to President Clinton, April 1998.

For over 40 years, the U.S. government produced plutonium for nuclear weapons at Hanford. This process generated enormous amounts of radioactive and chemically hazardous wastes. Beginning in 1944, Hanford workers began to store the most hazardous of these wastes in large underground tanks. Hanford's 177 waste storage tanks now hold about 54 million gallons of highly radioactive waste, nearly 60 percent of the nation's total. Sixty seven of these tanks have leaked an estimated one million gallons of waste into the soil.

Although all other federal sites with liquid high-level waste have treatment facilities, the process to remove and immobilize the wastes is barely underway at Hanford. Previous attempts to build treatment facilities have failed, causing at least 10 years in delays. It will take at least 30 more years to immobilize Hanford's waste and will cost billions of dollars. Success will require a national commitment on the scale of the effort to first build the atomic bomb or to put a man on the moon. Citizens of the northwest must hold the federal government to its commitment to remove this environmental threat and convince Congress to provide the funding necessary for this project.

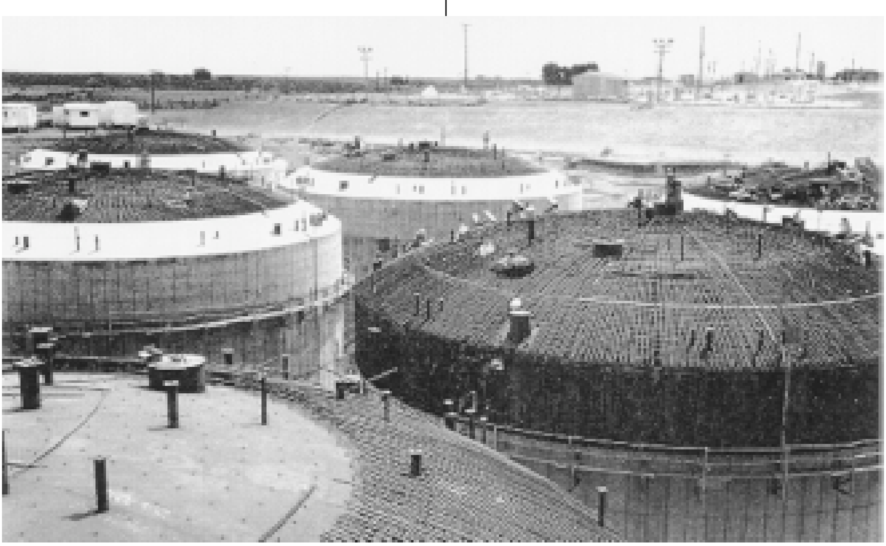
This booklet explains the history of Hanford's tank waste, the leaks and their impact, other tank safety issues, the difficulties associated with removing and treating the waste, and the consequences if the program is not successful.

Background

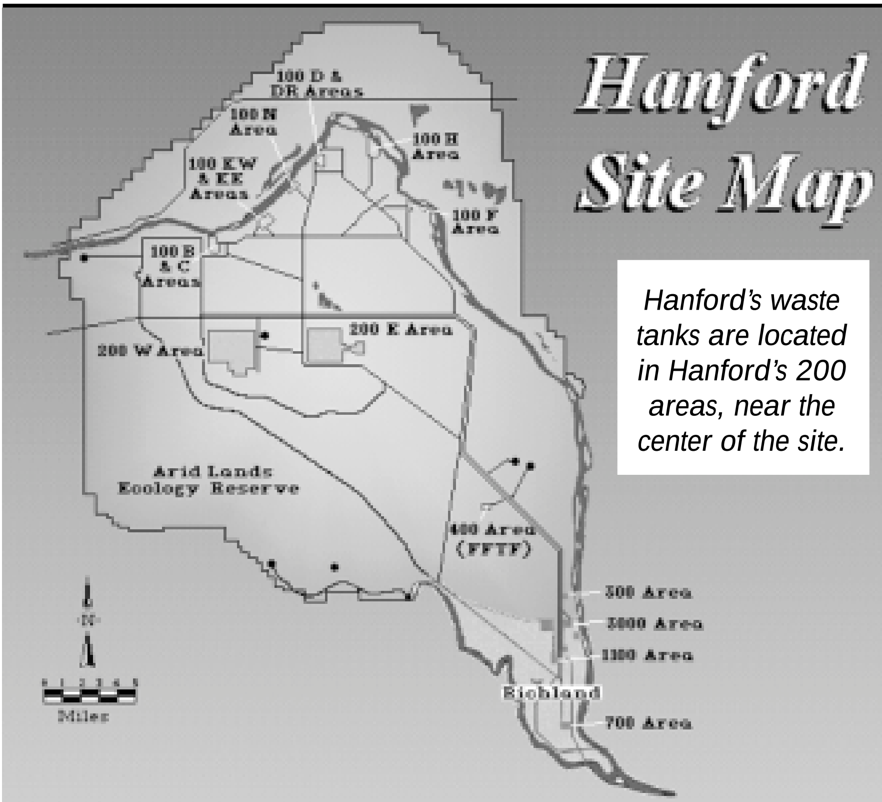
In early 1943, at the height of World War II, the U.S. government selected a remote area of southeastern Washington state as the location to manufacture plutonium for a nuclear bomb. Plutonium is produced when uranium fuel rods are irradiated in a nuclear reactor. The nuclear reactions produce heat and new elements, including plutonium. Eventually, nine nuclear production reactors were built along the banks of the Columbia River at Hanford. Hanford's first nuclear reactor began operation in September 1944.

A series of chemical processes are used to separate the plutonium from the other elements. This process began at Hanford in late December 1944. The uranium fuel was put into large tanks where nitric acid and other chemicals dissolved the fuel. Other chemical processes separated the plutonium from the other radioactive materials.

The chemical separations process created most of the high-level wastes which are



Hanford storage tanks under construction



stored in Hanford's underground tanks. These separation activities all occurred in Hanford's 200 East and 200 West areas, located near the middle of the site. The tanks are also in the 200 areas – clustered in groups of two to 16 tanks and referred to as tank farms. Underground pipes connect the tanks to other tanks, to other tank farms, and link the 200 East and West areas.

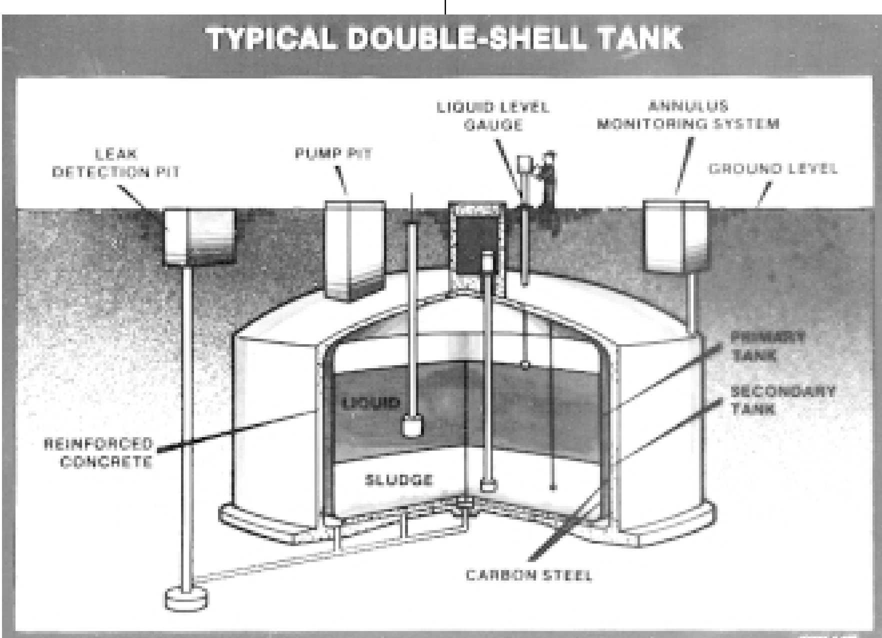
Much of the waste created in the chemical separation process had low levels of radioactivity. This waste was discharged directly to the soil. Other portions of the waste were highly radioactive and were mostly placed into the underground tanks.

Sixty four waste storage tanks were built during World War II to support the chemical separation operations. Forty eight of the tanks were 530,000 gallons in size. The remaining sixteen were much smaller, and hold 55,000 gallons of waste.

Following World War II, as the United States and the Soviet Union fought the Cold War, Hanford went through several expansions. Each expansion resulted in the construction of additional underground storage tanks. By 1964, Hanford had 149 underground storage tanks in 12 tank farms. The newer tanks were larger – 758,000 and 1,000,000 gallons in size.

> "The federal government's commitments to treating Hanford's tank waste have consistently been unfulfilled – treatment has always been delayed. Risk assessments have shown that both a catastrophic tank failure and continued leaking pose unacceptably grave risks to the Northwest's citizens, the environment, and agricultural economy. Delays only increase these risks." Hanford Advisory Board position expressed to DOE Secretary Peña and members of Congress, February 1998.

By the late 1950s, Hanford officials realized that some of the tanks, which were designed to be used only 10 to 20 years, had leaked. Eventually, to try and prevent future leaks, tanks with a double-shell containment were designed and built, beginning in the late 1960s. A total of 28 double shell tanks were built, mostly in the 200 East area. The newest of



these tanks have 50 year design lives.

The wastes placed in Hanford's underground tanks contain organic chemicals and solvents, radioactive materials (mostly cesium and strontium, along with uranium, plutonium, technetium and other elements) and miscellaneous wastes. Before the waste was pumped into the tanks, sodium hydroxide was added to neutralize acidic liquids. Otherwise, the acid would have quickly corroded the tanks.

Hanford's single shell tanks are cylindrical reinforced concrete structures with inner carbon steel liners just one-quarter to three-eighths of an inch thick. The domes of the tanks are made of concrete and do not include a steel liner. The smallest tanks are about 26 feet deep and 20 feet in diameter. The largest tanks are about 45 feet deep and 75 feet across.

The double shell tanks have two steel liners (with a single liner in the dome) and are reinforced by a concrete shell. All the tanks are covered with about 10 feet of soil and gravel.

There are also some smaller miscellaneous underground storage tanks at Hanford, ranging up to several tens of thousands of gallons in size.

Hanford's Waste Storage Tanks

200 East Area

-11 tank farms, 66 single shell tanks, 25 double shell tanks.

200 West Area

-7 tank farms, 83 single shell tanks, 3 double shell tanks

Single shell tanks

- 16 have a capacity of 55,000 gallons
- 60 have a capacity of 530,000 gallons
- 48 have a capacity of 758,000 gallons
- 25 have a capacity of 1,000,000 gallons

Double shell tanks

- 4 have a capacity of 1,000,000 gallons
- 24 have a capacity of 1,160,000 gallons

Tank Space Issues

Throughout its operating history, Hanford was plagued by a lack of sufficient tank space. By late 1946, half of the 64 tanks built during World War II were full and the others were nearly half full. Three primary methods were used over the next 40 years to free up or create tank space: dumping waste into the soil, evaporating liquids and building new tanks.

In the mid 1950s, ferrocyanide and other chemicals were added to some tanks in an effort to remove the radioactive elements cesium and strontium from the waste. The remaining waste was then presumably low enough in radioactivity to allow its discharge to the soil. This process was used to free up some tank space but would later result in serious safety concerns (see Section 5 on Watch List tanks).

Some tank space became available through a “cascade” process. Some of the tanks were built in cascades of three or four tanks. These tanks were connected with piping at different levels. When one tank filled to the level of the pipe, waste would flow through the pipe to the next tank. Since the solids, including much of the strontium and plutonium, would generally settle to the bottom, the waste that went to the next tank had less radioactivity. Liquid from tanks at the end of the cascade was then dumped into the soil.

At times the tank space needs were so critical that high-level waste was disposed directly to the soil. The initial belief was that the radioactive materials would attach to the soil particles and move very slowly, if at all. That didn’t prove to be the case. Direct releases were recommended at Hanford only in emergency situations.

In 1951, Hanford’s first two evaporators began operation. Liquid wastes were pumped to steam-heated pot-like evaporators. As the water boiled off, it left highly concentrated liquids containing solid salt crystals. Evaporated water was condensed and processed to remove contamination, then discharged to the soil. The concentrated waste was then pumped back into the tanks, where the salt crystals settled to the bottom and formed a saltcake. Some of this concentrated waste was also discharged to the ground.

Larger and more efficient evaporators began operations in the mid-1970s. Between 1950 and 1995, about 203 million gallons of liquids were evaporated from Hanford's tank waste.

Hanford's tanks currently contain about 54 million gallons of waste. The double shell tanks contain 18.6 million gallons of waste, mostly liquid. The double shell tanks total 31 million gallons in size, but not all of that space can be used. For example, because of safety issues associated with some tanks (see Section 5 on Watch List Tanks) no waste can be added to them. As a result, there is only about six million gallons of usable space available in the double shell tanks.

"What we have is a slow-motion disaster." Dirk Dunning, Oregon Office of Energy. (Tri-City Herald, August 30, 1998).

Some new waste is still being created through the cleanup of some of Hanford's facilities and is added to the tanks. Also, a variety of maintenance activities, such as the flushing of pipelines to prevent them from plugging, can create new waste.

Even with these efforts to reduce tank waste volume, it still became necessary to add more tanks. As mentioned earlier, by 1964, Hanford had 149 underground tanks. The 28 double shell tanks were put into service between 1971 and 1986.

In the early 1990s, it was believed six new double shell tanks were needed (at an estimated cost of about $435 million). An independent analysis conducted for the Hanford Advisory Board – a group of 32 varied interests advising the U.S. Department of Energy (DOE) and state and federal regulating agencies on Hanford cleanup – determined that additional tanks were not needed now. DOE eventually agreed.

However, unless treatment plants are soon built, Hanford will need more storage tanks. History has shown us that building new tanks is not the long-term solution – it simply creates an even greater legacy of wastes to be dealt with in the future. This expensive, dangerous and wasteful cycle must end.

Tank Leaks

Hanford's first tanks were built in 1944. They were expected to last from 10-20 years. Within that time period – in 1956 – the first leak was suspected. The leak, an estimated 55,000 gallons from tank U-104, was confirmed in 1959. By the late 1950s to early 1960s, several tanks were confirmed leakers. The largest known Hanford tank leak was 115,000 gallons in 1973. Despite other confirmed tank leaks in the following years, it was not until November 1980 that a ban on adding new waste to the single shell tanks was put in place.

An aerial view of a Hanford tank farm. Hanford's tanks are buried under a minimum six feet of dirt, which provides a radiation barrier for tank farm workers.

Tank leaks are discovered through one of three methods – monitoring wells, leak detection systems and drops in the waste level in the tanks. None of the methods has proven completely reliable.

There are two types of monitoring wells – those that reach to the groundwater, and those – called drywells – which do not. There are more than 760 drywells located around the single shell tanks. The detection of radioactivity in a drywell can indicate a leak from a tank. However, the waste must move laterally away from the tanks to reach a drywell, otherwise a leak may go undetected. It has only been in the past year and a half that tank waste has been detected in the groundwater monitoring wells.

Waste levels in the tanks can fluctuate for a variety of reasons. In 1997 and 1998, DOE determined that changes in the atmospheric pressure sometimes resulted in fluctuations in tank waste levels. In other cases, tank leaks have been detected because of drops in the levels.

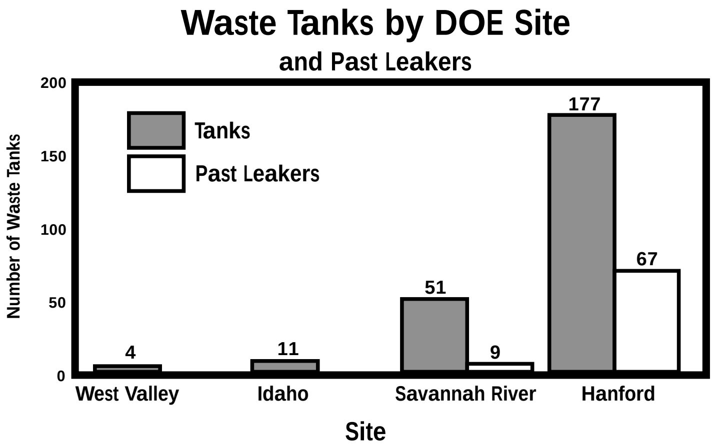
In all, 67 single shell tanks have been declared or suspected of leaking. Some tanks have leaked more than once. The total amount of waste leaked is estimated at 750,000 to 1,050,000 gallons of high-level waste and continues to rise as more information is gathered about the tank leaks. As long as waste remains in the tanks, leaks to the ground will occur. Some of that waste will reach groundwater within 10-20 years, and then travel towards the Columbia River.

> "We have been assured for many years that contaminants from the tanks were trapped in the soils beneath the tanks and were not traveling downward to the groundwater. This new information concerns us…(The) long term risk has escalated. The data shows that time is not on our side. We need to quickly retrieve and treat all the tank waste." Former Ecology Director Mary Riveland. (Tri-City Herald, February 20, 1996).

To reduce the threat of tank leaks, DOE, which owns the site, began to pump as much liquid as possible from the single shell tanks, and move it into the double shell tanks. This process is called interim stabilization. A tank is considered interim stabilized when it contains less than 50,000 gallons of drainable liquid and less than 5,000 gallons of liquid floating on top of the waste.

Currently, 119 tanks have been interim stabilized, including 64 leakers. Twenty nine tanks remain to be interim stabilized.

In 1989, DOE signed a cleanup agreement with the State of Washington and the U.S. Environmental Protection Agency. The Hanford Federal Facility Agreement and Consent Order (Consent Order), often called the Tri-Party Agreement, contains cleanup schedules called milestones. The Consent Order contains several milestones – which are legal obligations – related to interim stabili-



zation of the single shell tanks. In September 1997, DOE missed a milestone to begin interim stabilization of six tanks. Another milestone to begin pumping eight tanks by March 1998 was also missed. The Washington Department of Ecology denied DOE's requests for a new schedule, and in June 1998, Governor Gary Locke and Attorney General Christine Gregoire announced their intent to sue DOE. This was eventually resolved in October 1998 and a new schedule was agreed to by both parties in March 1999 in a Consent Decree.

One of the biggest concerns and unknowns is the fate of the wastes once they have leaked from the tanks. For years, DOE and its contractors insisted that the leaked tank waste had not reached the groundwater, despite concerns by others that this was the case. In February 1996, new tests showed cesium leaking from the tanks had gone deeper in the soil than had been thought. Cesium was detected in dry wells 125 feet below the surface, just 85 feet above groundwater. Earlier predictions were that cesium would attach to the soil and move very little, if at all.

In November 1997, DOE confirmed that waste from the tanks had reached groundwater from five tank farms. Two months later, it was determined that waste from three other tank farms had also reached the groundwater.

The fact that leaked tank wastes have traveled faster than earlier predictions means an escalation of the risk to human health and the environment, and an added urgency to remove the waste from the tanks as soon as possible.

Watch List Tanks

In 1989 and into the early 1990s, a series of concerns were raised about the potential for wastes in some of Hanford's tanks to ignite or explode. It was feared that an explosion or fire inside a tank could cause the dome to collapse and provide an outlet for radioactive materials to reach the environment.

By mid-1990, concern about these and other safety issues prompted a number of expert studies to assess the immediate threat. Most of the assessments indicated that the chance of a fire or explosion in a tank was possible, but not imminent.

Congressman (now Senator) Ron Wyden of Oregon successfully proposed legislation that created a "Watch List" of tanks. Tanks on the Watch List require special safety precautions because of the potential for release of high level radioactive waste through a fire or explosion. The Watch List was created in January 1991. There were four issues of concern: hydrogen, ferrocyanide, organics and high heat.

- hydrogen is generated through chemical reactions in the tank waste. At certain concentrations, hydrogen is flammable. At higher concentrations it is explosive.
- about 350 tons of ferrocyanide were added to two dozen tanks in the early 1950s to separate cesium and strontium from the waste. Under high temperatures and at certain concentrations, ferrocyanide can explode.
- more than five million pounds of organic chemicals were added to the tanks, mainly as a result of efforts to remove strontium from the wastes. At certain concentrations and at certain temperatures, organics can ignite.
- radioactive decay in the waste can create temperatures great enough to cause the waste to boil. If the tank were to leak, adding

cooling water would increase leakage to the soil. If cooling water was not added, the waste could heat enough to cause structural damage to the tank, possibly leading to a large release to the environment.

The original Watch List had 23 tanks listed for ferrocyanide, 23 for hydrogen, eight for organic and just one for high heat, tank C-106. In all, 52 tanks (47 single shell and five double shell) were on the initial Watch List. Some tanks were on more than one list. A few additional tanks were added to the Watch List later in 1991, in 1992, 1993 and 1994. No tanks have been added to the Watch List since May 1994.

"Every year waste remains in Hanford's tanks increases the risks of catastrophic releases, including explosions or leaks that will eventually poison the Columbia River." Gerald Pollet, Heart of America Northwest.

Many of the tank safety issues have since been resolved, and the number of Watch List tanks has gradually been reduced. DOE closed out ferrocyanide as a safety issue in September 1996 after determining that the concentrations of ferrocyanide were too low for a credible accident to occur. In December 1998 DOE closed the safety issue related to organic complexants.

The Watch List now contains 28 tanks.

The most notorious of the Watch List tanks was SY-101, located in the 200 West area. Chemical reactions in the waste create hydrogen, which was trapped in the solids at the bottom of the tank. When enough hydrogen was generated, it forced its way through the solids into the open head space of the tank. The concern was that during these hydrogen "ventings," which came to be known as tank "burps," the hydrogen concentration would be high enough to burn or explode if there was a spark inside the tank. These ventings occurred every 100 days or so.

In July 1993, a giant circulation pump was installed in SY-101. The 64 foot tall, 19,000 pound pump circulates liquid waste from the tank's upper layer to the bottom where jet nozzles discharge the fluid. There is still hydrogen generated in the waste, but for several years it vented in small steady releases, rather than in large infrequent releases.

Recently, the crust in SY-101 has grown over 20 inches in thickness. Hanford workers and regulators have been unable to verify the reason. These repeated problems clearly demonstrate that indefinite storage in Hanford's tanks is not an option.

In addition to the Watch List categories, there have also been concerns about whether the plutonium in any tank was concentrated enough to create a criticality (a self-sustaining nuclear chain reaction). No tank is believed to have that level of concentration.

Although most of the immediate tank safety issues have been resolved, the only way to successfully resolve the threat of tank leaks is to remove all waste from the tanks.

Photo from inside Tank SY-101

The Threat

Most people familiar with Hanford's tanks agree there are two kinds of tanks at Hanford – those that leak and those that will leak. All of the 149 single shell tanks are beyond their design life. Some are suspected to have little structural integrity left. The double shell tanks have yet to leak, but it is only a matter of time before they do. The degradation of the tanks will only continue.

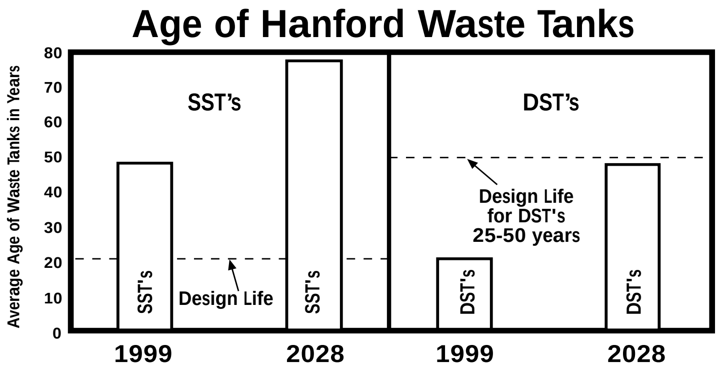
> "The health, environmental and economic consequences of the tank waste treatment and disposal program are extreme." Hanford Advisory Board advice to DOE, the U.S. Environmental Protection Agency and the Washington Department of Ecology, December 4, 1998.

Further releases to the ground, groundwater and the Columbia River are the inevitable result of tank failure. The contamination already in the groundwater could reach the Columbia River in as little as 20 years and continue for the next 5,000 years.

Past leaks, although significant on their own, represent only a small percentage of the waste still remaining in the tanks. The greatest opportunity to reduce this risk is now, while the waste is still somewhat contained. It will be much more difficult – perhaps impossible – and certainly much more expensive, to remove waste leaked into the soil and groundwater.

The tank waste cannot be removed and immobilized without treatment facilities. Without these facilities:

- waste in the double shell tanks cannot be removed and they will eventually fill and begin to fail
- the single shell tanks will continue to fail
- contamination to groundwater and the Columbia River will increase
- catastrophic risks from infrastructure failure and explosion will increase



The Tri-Party Agreement call for tank waste processing to be complete by 2028

The environmental consequences and economic risks of continued tank leaks are great. We can't risk the ecological health of the Columbia River on the hope that the waste will be slowed sufficiently by the soil or that it won't reach the river in concentrations that cannot easily be diluted. If the waste is not removed from the tanks, we know it will, at some point, reach the Columbia River. We cannot accurately predict when the waste will reach the river, or in what concentrations, just that it will eventually get there and that it will likely have significant effects on the groundwater, the Columbia River, other ecological resources, and on downriver users. Aside from the environmental damage and health risk, the perception of the river being contaminated could devastate the market for northwest agricultural products.

In addition to the threat posed by leaking wastes, we can't yet rule out the possibility of a tank explosion or a dome (the roof of a tank) collapsing. Although the risk of a tank explosion appears considerably less than in the early 1990s, when some of these risks were first identified, not all tank safety issues have been resolved. In addition, the risk of a dome collapse increases with time, as the tanks age and deteriorate. Either event could result in a release of radioactive materials to the air, posing a threat to human health and the environment, and an almost certain impact on marketing agricultural products grown in the region.

Previous plans to treat Hanford's tank wastes have failed. The citizens of the Northwest cannot afford another failure. There is simply too much at stake.

Treatment Plans

When the original Consent Order was signed in May 1989, it contained a schedule for construction and operation of a vitrification plant to immobilize Hanford's tank waste. This facility was scheduled to be operational in 1999, but after continual delays and lack of funding, was cancelled in 1993.

This was not the first time that immobilizing Hanford's tank waste had been considered. In 1958, the Atomic Energy Commission (a DOE predecessor), considered a plan to convert Hanford's B Plant into a facility capable of turning high level liquids into a solid ceramic. Unfortunately, that plan was not followed, again primarily because of funding concerns.

In 1994, DOE began to pursue a strategy of privatization for the tank waste treatment program, where a private company would pay all up-front design, construction and operating costs. The company would then get paid when they have turned waste into glass.

In September 1996, DOE entered into contracts with two contractor teams, one led by BNFL, Inc. and the other by Lockheed Martin Advanced Environmental Systems (LMAES). At that time, the contract was structured into two parts. Part A, planned for 20 months and ending in mid-1998, was to evaluate each company's technical, operational, regulatory, business and financial proposals. During Part B, planned for 10-14 years, the contractors would finance, design, construct, operate, and deactivate the waste treatment plants as a demonstration of the technology. Not all of the waste would be treated during Part B. This work would be done on a fixed-price basis. It was believed that the competition would help keep the price down.

In May 1998, DOE determined that the approach by LMAES had an unacceptably high technical risk and only BNFL was allowed to move forward with the design portion of the contract. In July 1998, DOE reached a tentative contract agreement with BNFL.

The agreement required major changes in both the project cost and schedule.

The estimated cost of $6.9 billion in 1997 dollars to treat 10 percent of the tank waste is an increase over earlier estimates. Start-up of some facilities is also pushed back by a few years. However, the facilities would be designed to operate for up to 30 years instead of as simply part of a five to nine year demonstration. The facility designs allow expansion of the plants' capacities at a later date, enough to eventually treat all the Hanford tank waste.

"We're putting at risk the Columbia River. The vitrification plant is not some hypothetical it-would-be-nice. It is, in fact, a necessity for us to move forward." Washington Attorney General Christine Gregoire. (Tri-City Herald, April 24, 1998).

The wastes will first be treated to separate the high-activity waste from the low-activity waste (waste which contains smaller amounts of radioactivity in large volumes of materials, but which still poses a hazard). Most of the waste will be low-activity. Through a process called vitrification, the high-activity waste will be converted to a glass-like material, then poured into steel containers to harden. These containers will be stored at Hanford until a national high-level waste repository is constructed. The low-activity waste will also be vitrified through a similar process. The low-activity waste will be permanently buried at the Hanford Site. By changing the waste into a solid form, the material will still be radioactive, but will no longer be mobile and able to enter the environment through the soil or groundwater.

BNFL has two years to develop the design, arrange financing, and determine a final cost. If DOE agrees with that plan and the price, BNFL would then vitrify 10 percent of Hanford's tank wastes by 2018. The waste would come from 11 tanks and includes some of the highest safety-risk tanks at Hanford. Construction of both a pre-treatment facility and a high-activity waste vitrification facility would begin in mid-2001. The pre-treatment facility would begin operations between August 2005 and April 2006. The high-activity waste vitrification facility would begin operation between February 2006 and February 2007. The low-activity vitrification facility would begin operation between January 2007 and January 2008.

Tank Waste Characterization

Hanford's tank wastes are chemically complex and varied. Through the years, several different chemical processes were used, different materials were added to various tanks for a variety of reasons, and waste was transferred from tank to tank.

As a result, the waste in any particular tank is likely to be different – and perhaps very different – from that of any other tank. This makes the process of treating and immobilizing the waste that much more difficult.

For effective treatment, the chemistry of the waste must be well understood. The presence of some metals in the waste or other irregularities could interfere with the formation and durability of the final glass. In addition, the hazardous constituents in the waste must be understood so that treatment can be designed to meet regulatory standards.

> "Those of us that draw our drinking water from the Columbia River don't believe we have…years to lose. We want to see a vitification plant built as soon as possible." Pam Brown, on behalf of the Hanford communities at a Hanford Advisory Board meeting, September 10, 1998.

To understand the chemistry of the tank waste, samples are needed from the tanks. This is a complex undertaking. The materials in the tanks not only are different chemically, but they are also very different in consistency.

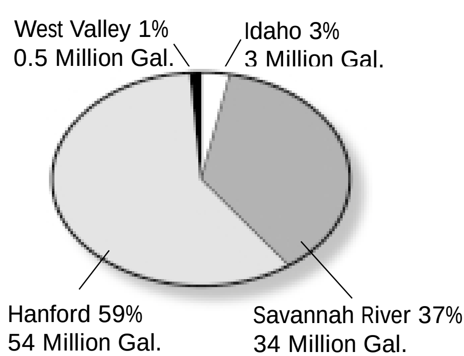
Sludge collects at the bottom of the tanks. It contains chemicals and radioactive materials that settled to the bottom. Sludges have a consistency ranging from peanut butter to cement. On top of the sludge is often a layer of saltcake, which is a moist but somewhat solid material made of water-soluble chemicals. Slurry in the tanks is a mixture of solid particles suspended in a liquid. It can be similar to a thick paste.

The liquids in the tanks are referred to as either interstitial or supernatant. The supernatant liquid generally floats on top of the slurry or saltcake. The interstitial liquid fills the spaces within the solid wastes and often is not easily pumped. Vapor fills the top of each tank. About half of the supernatant liquid has been pumped from the single shell tanks. As a result, what is left after the liquids are pumped is a combination of sludge and saltcake with some interstitial liquids.

This variety of waste types adds to the difficulties of taking and analyzing samples that are representative of a single tank or group of tanks. The presence of the solids means the tank wastes don't fully mix, and a sample from one side of a tank may not be representative of waste on the other side of a tank.

Characterization of the tank waste will continue into the future to support safety, retrieval, treatment and regulatory needs.

Hanford has more than half of DOE's high-level liquid wastes.



Tank Waste Retrieval

Getting the waste out of the tanks and to the treatment plants poses its own challenges. Because of the condition of the tanks, there is concern that the waste retrieval methods will result in extensive leaks and more waste entering the soil and the groundwater.

It should be possible to pump the liquids and slurry without too much difficulty, although the consistency of the waste could change during pumping and plug the pipes. Because the first phase of treatment will take waste from nine double-shell tanks (mostly liquid) and only two single-shell tanks, waste retrieval should not pose significant challenges in meeting BNFL's schedule of treating 10 percent of Hanford's waste by 2018.

The saltcake and sludge will eventually present significant challenges, especially in the tanks that have leaked. Hydraulic sluicing is strongly being considered to remove most of the hard saltcake and sludge. With sluicing, high-velocity streams of water will break the waste apart, and allow it to be pumped from the tanks. This process could severely damage the tanks and result in extensive leaks into the soil. Sluicing will require additional water to be added to the tanks. Solid wastes were successfully transferred between two Hanford tanks in early March 1999, as part of a demonstration of retrieval methods.

> "Despite years of monitoring and hundreds of boreholes into the vadose zone and the groundwater beneath the zone, DOE has a poor understanding of the extent of contamination in the vadose zone and whether the contamination is migrating." Letter from Ohio Senator John Glenn and Oregon Senator Ron Wyden to Congress' General Accounting Office (Tri-City Herald, July 17, 1997).

There is some consideration about installing some type of barriers around the single shell tanks to prevent leaks caused by sluicing. A variety of different barrier forms are being considered – including cement and cryogenics (freezing a layer of the soil). However, it's not certain how effective these technologies would be.

Other technologies, including robotic arms, are also being explored to retrieve waste while reducing the amount of water that would need to be added to the tanks.

One concern is that the contamination around the tanks is not well enough understood now to effectively judge the risks posed by past leaks. Without that knowledge, it is not possible to accurately predict the added risk to the environment that could occur from additional waste entering the soil as a result of the sluicing or other waste removal techniques. Efforts are now beginning to better determine the extent and spread of contamination in the vadose zone, which is the area of soil between the surface and the groundwater.

Tank Closure

Once the vitrification process is completed, and most of the waste is removed from the tanks and immobilized, there is still the question of what to do with whatever waste could not be removed from the tanks (called the "heel"), the tanks themselves, the underground piping, and the contaminated soil beneath the tanks. These decisions will need to be made at some point in the future. A number of options have received some study. For example, the empty tanks could be filled with cement or sand to keep them from collapsing, all pipes sealed, and a barrier of some type installed over the tanks to prevent intrusion and to reduce contact with water. A better understanding of the contamination levels in the vadose zone and the resultant risk is needed to help guide the decisions about final closure of the tanks.

"Protecting the Columbia River from the threat posed by Hanford's radioactive tank waste is one of the Department of Energy's highest priorities. Cleaning up these wastes is one of the most urgent and complex problems faced by the Department." DOE statement, February 1999.